3D Virtual Projection and Utilization of Its Outputs in Education of Human Anatomy

Jaroslav Majernik*

Department of Medical Informatics, Faculty of Medicine, Pavol Jozef Safarik University in Kosice
Trieda SNP 1, Kosice, Slovak Republic

*jaroslav.majernik@upjs.sk

Abstract

This paper deals with basic principles of virtual projection and its tree-dimensional (3D) technologies as well as with possibilities of their utilization in education processes. Main objective is to contribute to the discussion about positive and/or negative impacts of this progressive part of virtual reality on teachers and their students. Recent development and increasing accessibility of such technologies shows that they can play a considerable role in teaching concepts for both the distance and the traditional classroom learning environments.

Keywords

Virtual Reality; 3D Technology; Education; Human Anatomy

Introduction

The teachers of todays' modern information society often face the questions regarding the ways to improve education and explanation of their specialized topics. In that sense, we can think of questions like "What is a good teaching?" and "What is a good learning?". The answers are usually subjective, barely measurable, and strongly dependent on education content. However, many teachers agree that the students should be involved in active form of teaching, they should discuss particular themes, and they should propose possible solutions of discussed problems. A good learning includes topics designed as real situations and/or simulations of real contexts, project-based learning, abilities of national or international collaboration between students and many others. What the teachers still oppose is, whether the students really do the things outside of the classrooms, whether they do the tasks on their own, whether the contact between teachers and students can be primarily virtual etc. It is not easy to find answers, but a combination of face-to-face and distance education forms seems to be the best way how to satisfy both groups. Especially when modern technologies offer new opportunities to present education content and the students are really familiar with them. However, one of the most important factors affecting the ability to study medicine, especially human anatomy is imagination. A great number of modern books and atlases of anatomy already brought beautiful and lovely coloured illustrations, but they are still presented as plane. This may cause misinterpretations of some structures and/or misunderstanding of space depth. Nowadays, thanks to the virtual reality technologies, it is possible to offer new dimension in presentation of individual human body parts and/or systems. In this way, we use a 3D virtual projection system to enrich lessons of anatomy that are organized in lecture room for large groups of students and where the 3D animations are presented using large screen projection. To utilize such animations also out of the 3D projection system as well as out of the lecture room, we prepared versions of educational materials suitable for both off-line and on-line presentations.

Development in Education

The teaching as well as the technologies itself have overcome a long way of development and various improvements. The history always asked teachers to understand new technologies and to apply them into their classrooms. This required searching for meaningful ways of their utilization and for arguments that proved the teaching objectives will be achieved in more effective and more demonstrative manner. Naturally, the goals of lessons can be achieved also without recent technologies, but the students ask for them due to their todays' availability.

It is evident that the education aims are always almost the same. It is also evident that some teachers are opened to implement best teaching practices, while others worry to think about any change in the

traditional form of education. However, this second group includes many teachers that are specialists in their professional and scientific areas. Therefore, they should use assistance of their technically more skilled colleagues to create effective technology-teaching relationship. This is usually based on technologies that include virtual reality tools, simulations, interactive and dynamic teaching content, multimedia, but also educational games and social networks.

Several important factors should be considered while thinking of innovation using new technologies in the classroom. These factors include technological background, teacher's skills, innovation technology and target group of students. Technological background should offer information about technology infrastructure (i.e. computer network) in the school, possible usage of existing technological support, potential cooperation with other members of pedagogical staff etc. Teacher's skills consider possibilities to use innovative technologies, motivation to adopt new methods in education, preferred teaching style, and accessibility of supported teaching materials, manuals, and books related to the preferred modern technology etc. Innovation technology gives us information about the place of implementation, about interaction with pedagogical goals, similarity to current teaching methods, ways to support technology for the future etc. Finally, the group of students is the factor that answers the questions of their role in innovation process, demands on information technologies skills, knowledge of similar systems and/or tools, benefits and advantages regarding previous teaching forms, comfortable usage etc.

Even if there are challenges to use the latest technologies, the above mentioned factors should be considered carefully. A special attention should be paid on experiences one may obtain while studying functionality, options and properties of the technologies before they will be used as learning tools.

3D Virtual Projection

Todays' teaching methods are based on different innovative technologies including 3D visualisation technology. It can significantly improve current teaching methods by resolving common educational problems connected to the explanation and understanding of specific topics. Basically, such teaching is supported by 3D virtual environments that offer more illustrative presentations. The main consumers of 3D technologies are mostly higher education institutions that bring them to the applications through the scientific research and development.

There can be find a lot of technologies referred as 3D. Most of them use transformation of 3D content into the 2D pictures so they cannot be considered as real 3D. One of the truly 3D technologies is presented by stereoscopic 3D visualization that really shows all dimensions of the objects. The process of stereopsis was described by Charles Wheatstone in 1838. He formulated that this is the process by which humans perceive three dimensions from two highly similar, overlaid images. Based on this fact, Wheatstone developed his stereoscope and used it to view static images. Since that time, the 3D technology overcame long way and now we can watch 3D movies, play 3D games etc. Stereoscopic vision has been very important also in human development. Using it, we can identify position of surrounding objects in relation to our bodies. The importance of depth dimensions is obvious especially in cases when the objects are moving to and/or away from us. We can also see a little bit around solid objects without moving our heads and we can even perceive and measure space with such binocular vision. Various occupations also strongly depend on stereo vision including surgeons, dentists, but also civil engineers, architects, car drivers and many others.

In general, the 3D stereoscopic vision refers to how human eyes and brain create the impression of a third dimension. An example is shown in Fig. 1.

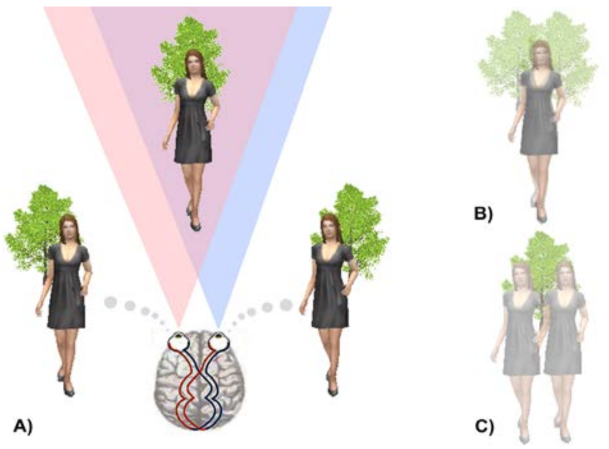

FIG. 1 A) STEREOSCOPIC VISION ANALYZED BY HUMAN BRAIN, B) VIEWS FOCUSED ON WOMAN, C) VIEWS FOCUSED ON TREE.

Human eyes are located approximately 50 mm to 75 mm apart and each eye sees a bit different part of the scene. It means that the image on one side (eye) is similar but slightly offset to the image on other side (eye). Therefore, for true perception of objects' depth, it is necessary to visualize not only one 2D image, but at least two separated images, i.e. one for each eye. The source image has to be recorded by multiple cameras or the scene must be generated from multiple views/positions. In addition, the presentation devices have to deliver the proper image to the proper eye while watching 3D scene. In this case, two slightly different images enter the human brain, which is able to determine all spatial dimensions (width, height and depth). The ability of depth perception includes perspective, overlay, shadowing, aerial perspective, relative motion, relative size, etc.

Modern 3D technologies try to replicate the same principles of how the human brain works with two different perspectives of the scene. All are designed to offer different perspectives of the same image into our individual eyes. However, while it is quite easy to figure out the disparity between the two images for our brain, it is a hard job to do the same with camera. Main task to be solved is to get individual images to individual eyes without the loss of information and space effect. The systems used to "create" 3D virtual environment refer to hardware and software that enable users to be immersed in. Such systems basically offer stereoscopic view, cover maximum proportion of user's field of view and allow controlling of the viewpoint in real time. Fig. 2 shows simplified classification of visual-based virtual reality systems.

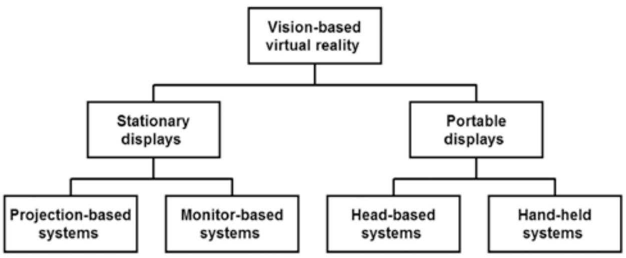

FIG. 2 MAIN CATEGORIES OF VISUAL-BASED VIRTUAL REALITY SYSTEMS.

Depending on the number of students and considering the teaching purpose we may assume the stationary systems will be preferred in the lecture rooms. Playing education movies and/or animations using virtual projection usually on the special silver-coated screens offers two main ways of how the 3D effect can be achieved, i.e. using anaglyph or polarized glasses.

Anaglyph is one of the first and one of the easiest methods of 3D stereoscopic visualization. The users watch the scene wearing red-blue (red-cyan or red-green) glasses. Scene to be visualized is prepared as mixture of images for left and right eye, each in particular colour (red-blue). Using coloured glasses the eyes get particular perspective and the brain process the 3D effect. The advantage of this approach is that the standard display units (monitors, projectors) can be used for projection.

Polarized glasses are much more common and are based on light polarization. Image for one eye is projected in horizontal direction while image for another eye is projected in vertical direction. Polarized glasses have corresponding polarization and allow horizontal polarization in one eye and vertical polarization in the other. Tilting the head may cause distort problems, but these can be solved using circular polarization (to make horizontal glasses displacement in tolerable range).

The stereoscopic view in monitor based systems (not limited to only small TV or PC monitors) can be achieved using passive or active visualization method.

Passive systems have display unit equipped with a thin, lenticular screen "attached" over the standard display. A lenticular screen is made up of a series of magnifying strips that show a slightly different perspective of the screen to each eye. In this sense, each eye can only see one half of the screen at any given time, because of interlaced images for the eyes. The quality of image may be reduced, but the method does not require expensive glasses.

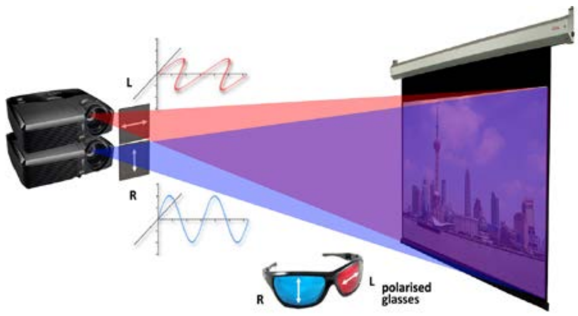

FIG. 3 PRINCIPLE OF PASSIVE STEREOSCOPIC PROJECTION.

Active stereoscopic visualization is based on fast switching between images intended for right and left eye respectively. Users wears special electronic glasses (shutter glasses) synchronized with projection devices that are special LCD monitors, TVs or projectors. Such glasses open and close shutter in front of a particular

eye, and thus it allows only one eye to see the screen at the same time. As for the high persistence of human vision and high switching frequency, the flickering (switching changes) is seldom noticeable.

FIG. 4 PRINCIPLE OF ACTIVE STEREOSCOPIC PROJECTION.

Recent developments in the area of 3D technologies improve the frame rates to minimize flickering effects and transform the underlying hardware from expensive huge devices to wide available hand-held devices such as laptops, camcorders etc. The developments are focused on products based on autostereoscopy and on products that do not require any glasses. In fact, 3D technologies have potential that can bring new dimensions into almost all activities of human life.

Utilization of Large Screen Projection

Well-organized teaching methods are usually affected by various conditions. These usually include well prepared teaching content, interaction with students and effective evaluation tools as well. We try to adopt them into our primary aim that is to improve teaching in human anatomy. Therefore, our activities are oriented on improvement of students' abilities to understand body composition, topography of anatomical structures as well as functions and interactions of individual body systems. To do this, we use the 3D virtual projection system, whose main aim is not to replace but to support traditional forms of education.

The system is installed in the lecture room with the capacity of 200 students. Wearing anaglyph glasses, the students feel an existence of 3D space and they are allowed to study human body systems in more detailed and illustrative forms. The system is composed of special large projection screen, pair of projectors, cluster of three computers and sound system. Other components of the system include teacher's workstation and 3D camera. The large screen projection shows final stereoscopic education movies and/or animations during lectures to the audience. Teacher's workstation allows us to process real captured contend as well as digital animations and to prepare required teaching content. 3D camera system is used to record real 3D content (e.g. dissections, surgery interventions).

FIG. 5 LECTURE ROOM EQUIPPED WITH LARGE SCREEN 3D VIRTUAL PROJECTION SYSTEM.

To create a 3D animated education material we use model of human body bought together with the 3D system from Slovakia Supercomputers s.r.o. The model is divided into the several parts, e.g. muscles, bones, nervous system, vascular system etc. Required parts of the human body are loaded into the SuperEngine (software to create scenes and to synchronize individual parts of the system) according to the aims of prepared presentation. Teachers/users can use the functionalities of the engine to make selected parts highlighted, transparent or invisible. Using space mouse, it is possible to organize movements, change viewing angles and prepare all the necessary effects in the scene in real time. All created scenes can be completed with texts and audio records and saved as dynamic 3D outputs.

The system also allows us to prepare and to present combination of 2D and 3D content, everything without the need to change glasses the users wear while watching education materials. Main functionalities of the system are summarized in table 1.

The most preferable way to use the system functionalities during lectures is presentation of prearranged materials. It's because the teachers do not want to spend any time by managing the scene in real time. However, the main reasons are that they worry to use it as something new and difficult and also there is a need to be skilled in using of the space mouse.

TABLE 1 FUNCTIONALITIES OF 3D VIRTUAL PROJECTION SYSTEM INSTALLED IN THE LECTURE ROOM

Function	Description
3D movies projection	presentation of real 3D movies recorded by 3D cameras (surgery interventions, medical treatment procedures, rehabilitation techniques etc.)
3D animated movies projection	presentation of 3D computer animations (usually materials prepared from 3D model of human body)
2D movies projection	presentation of scenes recorded using only one single non 3D camera
projection of 3D content in real time	presentation of 3D model in the case when no dynamic material was prepared before the lecture (teacher works with the system and with the 3D content during lecture)
live events 3D projection	presentation of real scenes directly from 3D camera (3D videoconference)

3D vs. 2D Education Materials

Even if the students' response is highly positive, the teaching using 3D virtual projection is limited by the time schedule of the lecture room as the system itself is not portable. Due to this, we decided to create also such versions of education materials that will be useable and playable also outside of the lecture room and its projection system. To meet these students' and teachers' needs, we create so called 2D versions of 3D educational animations. In the same way as the traditional 3D teaching movies, also these animated outputs can be equipped by additional audio and text comments and/or by teachers' explanations if necessary to improve the quality of resultant educational content.

In this process, the content and the design of existing 3D sources were upgraded before its transformation into the form of common (not stereoscopic) 2D movies. In some cases, we were forced to do completely new scenes as for the better presentation. Sometimes, there was also the need to add and/or to remove some parts of the model from the scene. Everything was done with the aim to create as best education and illustrative output as it can be and respecting requirements of anatomy teachers and the content of particular lecture. Thanks to the professionals and teachers we were able to define all needed educational scenes. Database of such transformed materials is available for students in the classroom of Department of Anatomy equipped with 10 personal computers and located close to the anatomy labs and dissecting rooms.

FIG. 6 COMPUTER CLASSROOM AT THE DEPARTMENT OF ANATOMY.

Furthermore, except of this local database, we create also off-line portable versions in the form of DVDs and an on-line form accessible via faculty's portal (http://portal.lf.upjs.sk/index-en.php). Using this approach, we expect to reach our primary goal that is to offer students the best possibilities for detailed study of human body, its organs and their topographical relations. However, these education materials will be repetitively useable during different education activities realized at the faculty.

A relatively small disadvantage (subjective opinion) of this approach is that the 3D information is missing and that the visualisation is reduced and is not as best as in 3D virtual space. Nevertheless, the students are allowed to see the content several times and discus it with their teachers in smaller groups. It is also used as good tool for preparation to practical lessons and exercises.

Except of computers, the classroom is equipped by multimedia presentation techniques and video-conferencing tools. These can be used to discuss the topics with colleagues/classmates wherever they are. The teachers also confirmed the camera system for audio-visual real-time transmission between dissector room and the classroom significantly improved the teaching of anatomy and brought new dimensions into the pedagogical processes.

Topics and Syllabus

Individual animated movies are prepared according to the syllabus of Anatomy guaranteed by Department of Anatomy. Thanks to the faculty's publication portal, the students have access to the presentations of individual subjects, so they can read the slides anytime and anywhere. Doing so, they can easily

memorize all explained topics. What the teachers were worried about is that the attendance during lectures will be poor, but the time convinced us that it was groundless apprehension as the current attendance is even better now and the students attend the lectures more prepared and also with the questions that can be meaningfully discussed.

Transformation of existing 3D educational materials and creation of new ones is organized upon the request of teachers. Currently, we prepare animations for the topics related to the systems of the head and neck that are published as presentations to the lectures at the faculty's portal and as it is shown in Fig. 7.

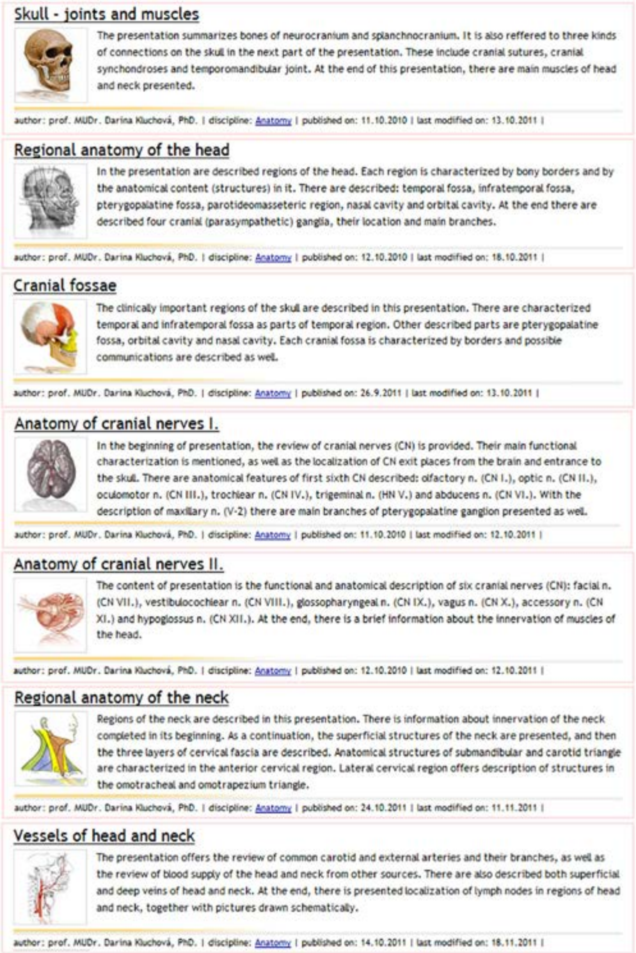

FIG. 7 SELECTED ANATOMY TOPICS PUBLISHED AT THE FACULTY'S POTRAL.

These topics include skull – joints and muscles (bones of neurocranium and splanchnocranium, cranial sutures, cranial synchondroses and temporomandibular joint, main muscles of head and neck), regional anatomy of the head (regions of the head, bony borders, anatomical structures, temporal fossa, infratemporal fossa, pterygopalatine fossa, parotideomasseteric region, nasal cavity and orbital cavity, cranial (parasympathetic) ganglia, location), cranial fossae (description of clinically important regions of the skull, characteristics of temporal and infratemporal fossa as parts of temporal region, pterygopalatine fossa, orbital and nasal cavity), anatomy of cranial nerves (review of cranial nerves, main functional characteristics, localization of CN exit places from the brain and entrance to the skull, anatomical features of olfactory n., optic n., oculomotor n., trochlear n., trigeminal n., abducens n., maxillary n., main branches of pterygopalatine ganglion, functional and anatomical description facial n., vestibulocochlear n., glossopharyngeal n., vagus n., accessory n., hypoglossus n., innervation of muscles of the head), regional anatomy of the neck (review of superficial and deep structures of the neck, description of borders of the neck, innervation of the neck, layers of cervical fascia, anatomical structures of submandibular and carotid triangle, describtion of structures in the omotracheal and omotrapezium triangle), vessels of head and neck (review of common carotid and external arteries and their branches, review of blood supply of the head and neck from other sources, description of superficial and deep veins of head and neck, localization of lymph nodes in regions of head and neck).

Complete educational materials are shared as combination of presentations (PPT, PPTX), lecture notes (DOC, DOCX, PDF) and animation (AVI - offline, FLV - online). An example of the anatomy lecture published at the faculty' portal equipped with 3D transformed animation is shown in Fig. 8.

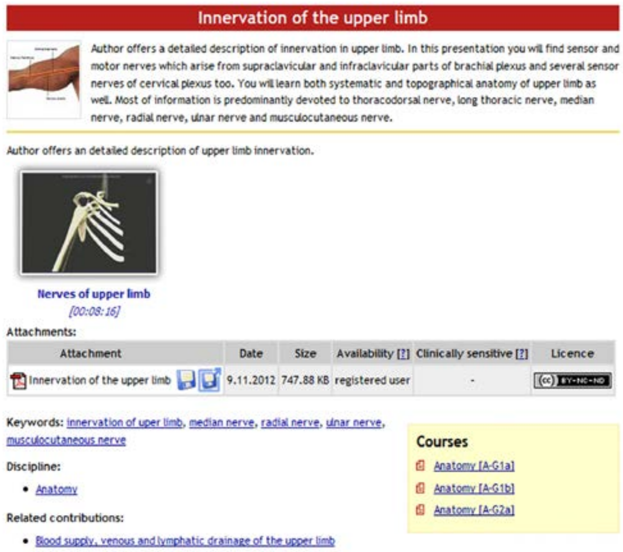

FIG. 8 EXAMPLE OF ANATOMY LECTURE PUBLISHED AT THE FACULTY'S POTRAL.

Discussion

Thanks to the information society and ubiquitous computer-based devices, the 3D technologies pave the way also in the education sphere. The teachers explore them and the students feel chance and benefits to improve their knowledge in the form of best practices. To understand the benefits and to decide whether to use such technologies in teaching activities, it is necessary to explore them, to work in team of interested colleagues and to recognise technical support at home institution as well.

Exploration should start by studying of documentation, features and capabilities of the technology. It is recommended to spend some time by playing with these technologies if possible, to visit product presentations or showrooms if any. One should compare utilization at other universities if exists and plan his/her own activities or simulate lessons, to imagine outputs and to have an idea of benefits he/she may reach.

Creating a team or searching for partners although at other departments will increase the chance of the technology acceptance. Collaboration is a good assumption of better ideas formulation, future usage and development, changes in curriculums, challenges for self-realization etc. Professional contacts can be found using internet sources or personally at the specialized conferences.

Technical support at home institution may bring resources to support technological activities, and usually well operational background. The comments of IT staff will help to recognize limitations and possibilities of existing infrastructure, specification may be adopted for particular lecture room or the activity may be presented on the web etc.

Teachers do not need to be teenagers to understand or to use modern 3D technologies. Many of them are frequently used by middle-aged adults. Therefore, the teachers should forget the prejudices and they should start to engage 3D technologies as something more than entertainment. These technologies have already proved their impact on the way we think, learn, and interact. They also demonstrated the tremendous potential they have in teaching and learning.

Even if the 3D technologies facilitate best practice learning there are still unexplored areas of usability. Nevertheless, there is no need to wait for the future to understand if and how these technologies can be implemented. Today's students use modern technologies, they found the benefits and strong results, so it is up to teachers to build steps towards the future.

Conclusions

Utilization of 3D virtual projection in our education activities, even if it is not organized periodically for all lectures, brought benefits for both the students and the teachers. According to our expectations, these methods increased interest of students in the presence forms of study as well as the quality of lecture content.

Direct students' response was also reflected by the teachers as they prepare more precise and qualitative better educational presentations. On the other hand, the students are directed to draw attention on important anatomical structures. The teachers also demonstrate that the lectures were significantly improved thanks to implementation of 3D virtual models and animations prepared according to the topics to be explained.

Visual perception equipped with the teachers' comments brought great didactic benefits, especially in the sense of visualization of individual organ sections and understanding of the space relationships. Separation of themes into the structuralized and smaller standalone monothematic education units brought also possibilities to improve practical self-study as well as the knowledge assessment using short quizzes and/or tests.

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Jaroslav MAJERNIK was born in Presov, Slovakia in 1977. He received his Master's degree in the field of electronics and telecommunications at Technical University in Kosice, Slovakia in 2000 and Ph.D. degree in bionics and biomechanics in 2005. His professional and research interests include biomedical engineering and medical informatics. He is author or co-author of seven books and more than 130 research works and projects in the fields of biomechanics and computer science. Currently, he acts as assistant professor and the head of Department of Medical Informatics at the Faculty of Medicine, Pavol Jozef Safarik University in Kosice, Slovakia. Dr. Majernik is a member of ESMAC, MEFANET Coordination Council and several national societies.